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Assistive Technology for the Voting Process

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Executive Summary

It is the right of every citizen in the United States over 18 to vote in their local, state, and federal elections. For most of us the processes involved in learning about candidates and issues, registering to vote, and casting our ballot, can be inconvenient and intrusive as we go about the routine of life. That said, we take the time and make the effort to participate in this most democratic of processes because we want to be counted for or against an issue or candidate we feel will affect our life in some way. Or we may do it simply because we feel it is our "civic duty." In any event, we want to participate in this process, and can generally do so independently.

Based on the 2010 American Community Survey from the US Census Bureau, there are an estimated 33.4 million people with disabilities in this country who are of voting age. While much progress has been made in voting accessibility over the past 30 years with the help of federal legislation (e.g., Voting Accessibility for the Elderly and Handicapped Act – 1984, Americans with Disabilities Act – 1990, Help America Vote Act – 2002) as well as many state initiatives, many barriers exist that can hinder or prevent people with disabilities from independently participating in the voting process.

This report discusses the nature of that process, what functional abilities one needs to carry out tasks associated with the process, and what assistive technology (AT) products are used by people with disabilities that provide them the functional ability to perform these tasks independently. Additionally, this report tries to provide the reader a sense of the context of life with a disability through which the voter must navigate to successfully carry out voting. For some, effective AT products may not be enough to smooth the path to voting success.

This report not only looks at existing products, but also some new and emerging technologies that may have potential in providing people with disabilities a higher level of independence and function when it comes to voting. The primary mechanism for providing this information is through a series of tables that attempt to relate disability type, appropriate AT, and the voting-related task or tasks that must be carried out throughout the process. An alternative set of tables summarizes the functional abilities required to carry out voting activities into the following categories: transportation; reading text; communication (receptive and expressive); writing (generating text); physically manipulating paper, tools; and executive functioning. Assistive technologies needed by people with disabilities to carry out these activities are listed for each category.

Introduction

Assistive technology (AT) is a term describing software and hardware products and devices used by people with disabilities. They use these products to perform tasks they would not otherwise be able to perform due to some functional limitation caused by their disability. AT also plays a role in facilitating voting for many people with disabilities. However, more people with disabilities could likely participate in the voting process if they had access to appropriate AT or training on how to use it effectively to facilitate participation in the voting process.

Voter Personas

In an effort to provide perspective regarding the experience of voters with disabilities, and to illustrate how AT might be used by voters with certain types of disabilities, this report presents three different personas of people with disabilities, each of whom is interested in voting in an upcoming election. While what is characterized in these examples represents a small portion of voting tasks, disabilities, and AT, the reader can get a flavor of what people with disabilities face as they move through the voting process, how vital AT can be to their capacity to participate fully, and also how subtle differences in the voting process from state to state may influence successful participation.

Tommy in Ohio

Tommy is a 38 year old man that lives with his 40 year old wife and 10 year old daughter in a small 3-bedroom home in suburban Cincinnati. Tommy works full time at the City Department of Health overseeing Statistics and Records in the Community Health Services Division. He likes to garden, walk his dog, play video games with his daughter, go to Reds games, and listen to bluegrass music. Tommy has moderate cerebral palsy, which makes it very difficult for him to walk significant distances, and to push a manual wheelchair. While he gets around using forearm crutches for short distances, he needs his power wheelchair most of the time.

Tommy's speech is significantly impaired. That said, he speaks slowly and works at being understood, and prefers speaking to using an augmentative/alternative communication (AAC) device. He has some spasticity in his arms and hands, which makes it difficult to grasp small objects, like pens, paper, coins, etc.

Tommy has always voted in national elections, as well as some local elections. He reads information on candidates and issues using his computer and the internet. He can vote absentee in Hamilton County (as can anyone), but not independently, as this process involves writing on a form, and he cannot do that legibly. To vote privately, Tommy must go to a polling location (local elementary school gym), bring identification documents, and use a direct-recording electronic (DRE) voting machine with a voter verifiable paper audit trail to cast his

ballot. The DRE voting machine has a place to plug in two switches that can be used to control the machine and scan and select choices on the ballot. He could do this, but would really prefer to have a way to vote at home on his computer.

Clara in Kentucky

Across the Ohio River in Kentucky lives Clara. Clara lives alone in a condo a few miles away from her daughter's house. She is 72 and generally healthy, but has some trouble remembering things, is a bit hard of hearing, and has difficulty reading because of her eyesight. She has some arthritis, which makes moving around sometimes painful and difficult. She doesn't drive anymore, but the condo has a shuttle that takes her where she needs to go. Otherwise, her daughter will drive her.

Clara would prefer to vote using an absentee ballot, as she could then fill her ballot out at home and mail it in. This would save her the hassle of getting out to a polling place on a certain day. Her county indicates on its website:

> *Voters unable to get to the polls on Election Day are eligible to vote by paper absentee ballot. You must meet one of the following requirements:*
>
> - *Due to advanced age, disability, illness or medical emergency.*
> - *…*

Her application for an absentee ballot was denied by the County Clerk, as she was not deemed old enough, or disabled enough to qualify. An issue in an upcoming local election is important to her, but it will likely be crowded at the polls at the time her daughter can take her, so she may not vote.

Clara has a hearing aid, a wheeled walker with a seat, and software on her computer that lets her enlarge text. She uses several types of assistive technology effectively, but the general hassle of getting ready to go out, then going out, waiting in line, and having to use some unfamiliar voting device may keep her from voting.

Mark in Missouri

Mark is 32 years old and has been blind since birth. He lives by himself in St. Louis and works for a disability rights organization located in the city. His personal AT consists of his cane, JAWS (a computer access tool for the blind that reads text on his home computer screen), a scanner and optical character recognition software that reads printed text, and a portable Braille note taker he uses with his smart phone. Mark's condo is downtown. He is a competent navigator of the city with the help of GPS on his smartphone. He is very interested in the upcoming local election given some key ballot issues that will impact people with disabilities. He registers to vote by filling out the online registration form on the county website. He manages this with the

help of the JAWS software program. He prints the completed form and an envelope, and mails it to the county office.

On Election Day he goes to the poll with a friend who lives in his condo. There he is able to use a touch screen voting machine that has controls with Braille characters and reads the ballot contents and instructions to him. He is able to vote independently with some help getting directed to the voting machine.

Assistive Technology to Address Different Barriers

The examples above illustrate both the critical impact of AT on the functional independence of persons with disabilities in voting, but also the limits on that impact in solving all barriers to voting faced by people with disabilities. That said, whether a person has a **sensory**, **physical** or **cognitive** disability – or some combination of these – there are assistive products and strategies available to make it easier – or possible – to do what is required to register to vote, to become educated about the issues and candidates, and to carry out the process of actually casting his/her vote.

Sensory impairment

For people whose disability is primarily sensory, difficulties throughout the process involve perceiving information needed to be able to register, understand issues, assess candidates, and understand where and how to vote. The AT tools they use during the process help to facilitate their reception of this information, providing it as speech or Braille for those who are blind, or text for those who are cannot hear. Increasingly, AT for these populations is digital and computer based, as much of the information to be accessed is in digital form, or can be captured and translated into digital form that can then be presented to the user in alternate sensory formats (e.g., auditory, touch).

Motor impairment

People with movement impairments have different access issues. AT for them must augment or replace targeted force and motion activities that must be performed throughout the voting process, such as signing one's name, delivering a document, using a computer, or operating a voting machine. Accommodating these kinds of functional needs can involve very simple AT or very complex AT. A simple AT solution for someone with a C-5 spinal cord injury may involve using the end of a stick secured to their hand with an Ace Wrap (elastic) bandage to hit the buttons on a keyboard (or voting machine). However, if they have no use of their hands or arms (e.g., someone with a complete C-3 spinal injury), they may need to use voice commands or an eye gaze system through a computer to carry out voting tasks controlled by software.

For most people with disabilities who are not able to vote at the poll – for whatever reason – voting at home on a computer or mobile device would allow them to use their own AT in an effective way to record their vote. At the poll, other than using basic or more conventional adaptive aids like hearing aids, hand-held magnifiers, and simple augmentative and alternative communication (AAC) devices, such voters usually do not have the opportunity to use their personal AT to facilitate voting. Voters with visual impairments cannot load their personal copy of JAWS, set up specifically to address their adaptive needs, or other screen reading or visual aid software on the electronic voting machine.

On the other hand, people with upper extremity motor impairments can often use AT they use in their daily life to facilitate voting at the poll. They may use low-tech adaptations such as a head stick, a mouth stick, or cuffs that hold a stylus or pen (shown in figure 1).

Figure 1: Head stick, mouth stick, and cuff with stylus

Or they may bring their own switches for controlling the voting machine. Some voting machines offer two 1/8 inch jacks that allow such a user to plug in their own switches to control the machine and cast their vote. In spite of this accessibility feature being offered at the polls to those who need it, it may do little to encourage voters with these types of impairments to come to the poll. Voting patterns of people with disabilities offer clues as to the types of disabilities that may most negatively influence levels of voting. One of the disability groups that has the highest percentage of non-voting was characterized as people with a self-care disability (13.5% fewer people with this type of disability voted in the 2010 elections).[1] While the Census Bureau does not specify this, it is probable that these are people likely to have an impairment of upper extremity mobility. As such they would include those people who may need to use a voting machine equipped to operate using dual switches.

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[1] Thad E. Hall and R. Michael Alvarez, "Defining the Barriers to Political Participation for Individuals with Disabilities," Information Technology and Innovation Foundation Accessible Voting Technology Initiative Working Paper No. 001, 2012, http://elections.itif.org/reports/AVTI-001-Hall-Alvarez-2012.pdf.

While voting machines that offer this dual switch option provide an accessible mechanism for these users to cast their vote, the voting process can be longer, less private, and more onerous for people with these types of functional limitations. The user must learn how to coordinate use of the two switches to navigate the ballot, select their candidate, and cast their vote. The process itself is usually lengthened by the need for a user interface that must present the switch user with every option available. The user in this case may not be able to skip over measures and candidates they know they are not interested in. Casting the ballot may involve paper handling, and handling paper ballots can require assistance. Add to this the potential for poll workers who are unfamiliar with operating the machine in this way, and a crowded poll, and it becomes apparent that voting from home may be a far preferable experience than going to the poll. And, in fact, the data shows that people with disabilities vote by mail at much higher rates than voters without disabilities.[2]

Cognitive disabilities

Many people with cognitive disabilities may have other physical or sensory impairments, but the discussion under this heading is only about products and devices that address manifestations of cognitive impairment such as memory loss, decrease in executive function, limited ability to focus, and also such things as reading disabilities and limited problem solving skills.

The types of AT that exist currently to address these impairments are somewhat limited. However, there are adaptive aids that can enhance the function of people with memory loss and executive function difficulties. For example, PDA and phone-based apps can remind users of appointments and tasks to be completed, and prompting apps can be set up to provide audio/visual guidance to help users carry out tasks and procedures. Within the voting process, these technologies could be used to inform the voter of pertinent political events to participate in or articles to read. These apps might remind the voter to register to vote or go to vote at a certain time and place. And a well-written mobile device app might be used to guide them through the process of voting while at the poll.

Emerging Technologies

Advances in technology will continue to impact the way people with disabilities vote. Certainly the explosion of the mobile computing and communication technologies will influence voting methods and practices. The functionality of the mobile devices, such as smart phones and tablets, continues to broaden as developers create more task-specific apps. The development of apps that facilitate the successful completion of voting tasks could provide voting access for

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[2] Ibid.

people with disabilities at a relatively low cost. For example, apps might facilitate reading the ballot and instructions, voting by voice, and verifying the results.

The potential for using mobile devices in elections was demonstrated in a recent experiment in Oregon where iPads were used by people with disabilities to vote in their homes.[3] In this pilot, poll workers transported these tablet computers to the homes of people with disabilities who could not get to the polls. In the future, using these devices at the poll site could offer voters a user interface they may be more familiar with. Such a voting machine would have the capacity to accept a variety of accessible controls, allowing people with disabilities to bring their own AT or use alternative controls supplied by the poll.

Computing and sensor technology advances will make it possible for voters with accessibility needs to have electronic voting machines automatically present them with the customized control and user interface they need to successfully complete the process.[4] During registration they could be given an RFID tag or QR code that contains the specifics of the type of machine configuration they need in order to use the voting machine. Once they get to the voting booth, the machine accesses this information by sensing or scanning the tag or code and configures the machine to accommodate the voters' accessibility needs, be it larger font, different color and contrast, audio output, switch scanning, or other specific voter needs.

Voice recognition technology has evolved into an increasingly accurate and effective means to commit speech to intended action or text. If privacy issues and concerns could be effectively addressed, it could offer promise as a relatively speedy alternative means for voting for people who lacked hand and arm function. Addressing privacy could center on the design of the interactive user interface of the voting machine. For example, voting selections could be made by speaking the candidate's randomly assigned number, preventing others from overhearing who the voter selected.

Other emerging technologies have the potential to be useful to voters with disabilities. These technologies include:

- Visual flat screen display readers: Visual flat screen displays (VFSDs) are often difficult for current photo scanning/character recognition systems to capture and read accurately due to the nature of the screen refresh. A mobile device that can read text on

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[3] Katharine Q. Seelye, "Oregon Tests iPads as Aid to Disabled Voters," *The New York Times*, November 16, 2011, http://www.nytimes.com/2011/11/17/us/oregon-tries-out-voting-by-ipad-for-disabled.html.

[4] For a similar proposal outside of the voting context, see the Global Public Inclusive Infrastructure (GPII) project at http://gpii.net.

VFSD that voters could encounter on voting machines would assist voters who are blind or have trouble understanding written text.

- Customized accessible interfaces for public systems: Electronic voting machines could automatically configure a customized accessible interface before an individual begins to vote. Configuration would be determined based on information provided during voter registration or when signing in.

- Customized accessible interfaces for personal devices: A voter's personal mobile device (e.g., phone or tablet) could pick up a signal at the polling place that tells the device the voter is at the poll. The voter could then download a user interface from the cloud designed for use by voters with a specific type of disability or functional limitations. The voter uses this as a remote to carry out the voting process.

- Gesture recognition: Gesture recognition could be used as an input method for voting machines (e.g., as used in computer game systems such as Wii and Kinect).

- Augmented reality: Voters could use a phone or tablet to take a picture of a voting machine and then be supplied with additional graphic images and text that could assist them in using the machine (e.g., directions for printing, depositing ballot, etc.).

- Way-finding with mobile devices: Voters could use way-finding technology on mobile device to provide guidance and direction to tagged equipment at the poll (e.g., using RFID tags).

Accessibility Benefits of Convenience Voting

Finally, it is worth considering that having more accessible and usable voting technology and processes at the poll may not have much of an impact on the percent of people with disabilities that vote. And while people with disabilities may use various assistive technologies that provide access and the capacity to participate in life activities, the process of voting carried out at the poll does not allow for much integration of these personal assistive technologies to render it accessible for the individual voter with a disability. The hassle and effort required by PWDs to get prepared to leave their home, to get to the poll at an appointed time, and to potentially wait in line for an extended period may continue to keep these numbers low. For people that must use dual switches to control the voting machine and move through the voting tasks, there is the added burden of the extensive time it can take (depending on number of choices, ballot measures, etc.) to move through that process.

Convenience voting – voting absentee or voting early – is certainly a more accessible option for voting for many people from a variety of disability groups. That said, there are still people who

cannot vote independently via the absentee paper ballot (e.g., people who are blind or have severe upper motor impairments), and early voting still requires the voter to go to the poll and use the machine they have. Offering voters with disabilities the opportunity to use their own computer, with their own computer access technologies would facilitate accessible voting for many individuals, although voting access gaps would still remain for those who did not own or have access to a computer and the internet. Ultimately, it is likely there will always be voters for whom human assistance may be required to complete the process – or at least deemed by the voter as their best option for ensuring that they can indeed cast their vote.

Assistive Technology for Voting Activities

In an effort to summarize what AT people may use throughout the voting process to facilitate various voting related tasks – both now and in the future – the author has created two sets of tables.

Tables 1 through 6 correlate three factors associated with the issue of voting accessibility – the type of disability needing accommodation, the type of voting process task to be accommodated, and the assistive technology that could be employed to accommodate that task. The tables show a breakdown of the voting process into tasks and activities a voter may carry out when voting at the poll. These activities are correlated with assistive technologies voters with specific types of functional limitations might use to carry out each particular task (e.g., someone who is **blind** may use a **computer with screen reading software** to **access a registration form online**).

Each table is associated with one type of disability involving one fundamental sensory or physical functional limitation. These include:

1. Mobility (lower extremity)

2. Mobility (upper extremity)

3. Vision

4. Hearing

5. Deaf/Blind

6. Cognitive

Table 7 contains information similar to Table 1, but it is organized differently to be more broadly inclusive of all types of voting-related scenarios – not just voting at the poll. It is constructed around six functional task categories: transportation, reading text, communication, writing, manipulation of paper and tools, and executive function. These categories generally

embody the functional tasks that must be carried out as a voter moves through the voting process, whether voting at the poll on Election Day or participating in convenience voting (e.g. voting absentee or at an early vote center).

As will become apparent, the voting tasks listed for casting a ballot describe in-person voting. While absentee processes are not listed, assistive technologies for paper handling processes done at home are listed for similar activities associated with voting.

The tables reveal a number of accessibility gaps in the process for each disability group, and hopefully identification of these gaps may stimulate work towards finding solutions. It is the author's intent that these tables be a thought-provoking start to something more complete, and of eventual significant value to efforts to enhance voting accessibility for all people with disabilities.

How to read the tables

The first column in each table lists the unique tasks and activities identified in the voting process. The rest of the columns show assistive technology devices that someone with that disability may employ to perform the task or access the information.

There are three columns for AT. The first two (ASSISTIVE TECHNOLOGY headings) are current or common assistive technologies. One of these columns indicates personal technology that would typically be owned by the person with the disability, who would travel with it to the polling place. The next column indicates technology that may be at the polling place, for use by the public, and provided by the polling place or some other entity.

In these two columns:

- N/A indicates that for that particular disability group, there is no applicable functional limitation (and therefore, AT) associated with that task.

- A question mark (?) in a cell indicates that there may not currently be any assistive technology that addresses that functional limitation associated with that task.

Here it may be helpful to better define some of the AT listed.

AAC stands for augmentative or alternative communication, and refers to any device used by someone who cannot speak, that provides another way for them to communicate. Typically we may think of a portable electronic device that has words, pictures, or symbols that when selected by the user, causes the device to speak a word, phrase, or sentence.

Also, one AT description listed in these columns may need clarification. **Adaptive computer access software and/or hardware** refers to those existing AT tools that offer alternate

computer access to people that cannot (or find it difficult to) use a computer by typing with their ten fingers.

Head stick or mouth stick refers to a simple device used by someone with very limited or no control of their arms and hands. To use a key pad of some sort, the user might hold a specially designed lightweight rod, one end between their teeth or strapped to their head, using the other end to press keys on the keypad. While exceedingly low-tech, such devices offer many such individuals access to many products and devices they would otherwise be unable to use.

Mousekeys is a software program that permits the user to use keyboard buttons to perform functions the computer mouse would perform.

OCR stands for optical character recognition. This refers to software that takes text that has been scanned into a mobile device or computer, and turns the scanned image into a text file that can be read or printed.

TDD stands for telecommunications device for the deaf.

The final column in the table lists some emerging technologies already discussed above. These are technologies not yet widely used to enable voting participation by people with disabilities, but should be considered as potential tools for facilitating some part of voting participation for people with some type of functional limitation. These include products currently on the market, but also more fundamental technologies that could potentially be incorporated into assistive technology designs that would enhance the accessibility of the voting process for some people. They are identified in the tables in activities where they might be helpful to voters.

For convenience, these technologies are listed below:

- **Visual flat screen display readers**: Visual flat screen displays (VFSDs) are often difficult for current photo scanning/character recognition systems to capture and read accurately due to the nature of the screen refresh. A mobile device that can read text on VFSD that voters could encounter on voting machines would assist voters who are blind or have trouble understanding written text.

- **Customized accessible interfaces for public systems**: Electronic voting machines could automatically configure a customized accessible interface before an individual begins to vote. Configuration would be determined based on information provided during voter registration or when signing in.

- **Customized accessible interfaces for personal devices**: A voter's personal mobile device (e.g., phone or tablet) could pick up a signal at the polling place that tells the device the voter is at the poll. The voter could then download a user interface from the cloud

designed for use by voters with a specific type of disability or functional limitations. The voter uses this as a remote to carry out the voting process.

- **Gesture recognition**: Gesture recognition could be used as an input method for voting machines (e.g., as used in computer game systems such as Wii and Kinect).

- **Augmented reality**: Voters could use a phone or tablet to take a picture of a voting machine and then be supplied with additional graphic images and text that could assist them in using the machine (e.g., directions for printing, depositing ballot, etc.).

- **Way-finding with mobile devices**: Voters could use way-finding technology on mobile device to provide guidance and direction to tagged equipment at the poll (e.g., using RFID tags).

Table 1: Mobility impairment (lower extremity)

This table highlights the basic need for those adaptations and technologies that facilitate physical access to the poll. The assistive technologies and adaptations listed here have been around for many years, are fairly prevalent, and are generally low tech in nature. That said, they are all fundamental to the ability of the individuals in this group to independently vote in person at the poll, and in the case of architectural accessibility features, many are mandated by law.

Table 1: Mobility impairment (lower extremity)

TASK	ASSISTIVE TECHNOLOGY (personal)	ASSISTIVE TECHNOLOGY (provided to public or at polling place)	EMERGING TECHNOLOGY
REGISTERING TO VOTE			
1. Reading text from paper forms, websites	N/A	N/A	
2. Writing text, signing paper forms	N/A	N/A	
3. Filling out online forms (computer typing, mouse, stylus)	N/A	N/A	
4. Travel to registration site	Wheelchair, vehicle adapted with hand controls	Accessible public transportation (bus, accessible cab)	
5. Enter registration site	Walker, wheelchair, cane	Ramp, lift, automatic door, lever door handle	
6. Mailing forms	Walker, wheelchair, cane	N/A	
7. Calling election office	N/A	N/A	
8. Pull documentation together for registration	Walker, wheelchair, cane	N/A	
LEARNING ABOUT CANDIDATES AND BALLOT ISSUES, LEARNING ABOUT HOW ELECTIONS WORK (PROCESS)			
9. Reading text from books, newspapers, magazines, websites, email, social network sites, TV	N/A	N/A	
10. Hearing reports from TV, radio, websites, live events, direct and phone contact with others	N/A	N/A	
11. Reading graphics, text from snail mail, websites, newspapers, TV	N/A	N/A	
12. Attend political rally or town hall meeting to hear candidates	Vehicle with hand, adapted controls; Walker, wheelchair, cane	Accessible public transportation (bus, accessible cab); Ramp, lift, automatic door, lever door handle	
FINDING OUT WHEN AND WHERE ELECTIONS WILL BE HELD AND OPTIONS FOR VOTING			
13. Hearing information from others directly (face to face, phone), TV, radio	N/A	N/A	
14. Accessing a calendar and assigning appointment time/place to a date.	N/A	N/A	

GETTING TO THE POLLING SITE			
15. Travel to poll site	Vehicle with hand, adapted controls	Accessible public transportation (bus, accessible cab)	
16. Enter poll site	Walker, wheelchair, cane	Ramp, lift, automatic door, lever door handle	
SIGNING IN AND GETTING YOUR BALLOT			
17. Maneuver in polling site	Walker, wheelchair, cane	N/A	
18. Locate, identify, access needed documents	Walker, wheelchair, cane		
19. Present documents at poll	N/A	N/A	
20. Position for access to voting booth/machine	Walker, wheelchair, cane	N/A	
21. Speak to poll worker	N/A	N/A	
LEARNING HOW TO MARK YOUR BALLOT			
22. Read paper instructions	N/A	N/A	
23. Read instructions on digital machine	N/A	N/A	
24. Hear instructions from poll worker	N/A	N/A	
25. Hear instructions from digital machine	N/A	N/A	
CASTING YOUR BALLOT			
26. Mark paper ballot with pen, stylus	N/A	N/A	
27. Type on digital machine	N/A	N/A	
28. Press buttons on machine	N/A	N/A	
29. Flip levers on machine	N/A	N/A	
30. Transport paper ballot to scanner or poll worker	Walker, wheelchair, cane	N/A	

Table 2: Mobility impairment (upper extremity)

Voting involves the intake of information by the voter, subsequent documentation of the voter's choices and decisions, and verification by the voter that such choices and decisions were accurately and effectively recorded. For voters who cannot use their hands, the benefits of using a computer (including smart mobile devices) to perform these tasks become apparent when one recognizes the availability of effective adaptive computer software and hardware designed to facilitate computer use by people with this type of impairment.

Table 2: Mobility impairment (upper extremity)

TASK	ASSISTIVE TECHNOLOGY (personal)	ASSISTIVE TECHNOLOGY (provided to public or at polling place)	EMERGING TECHNOLOGY
REGISTERING TO VOTE			
1. Reading text from paper forms, websites	Book stand, copy stand, mouth stick	Book stand, copy stand	
2. Writing text, signing paper forms	Cuff with pen holder, mouth stick, signature guide	Cuff with pen holder, mouth stick, signature guide	
3. Filling out online forms (computer typing, mouse, stylus)	**Adaptive computer access software and/or hardware :** Speech recognition software, head stick, mouth stick, cuff with stylus holder, head pointing system, eyegaze system, Mousekeys, onscreen scanning keyboard with switch(es)	Speech recognition software, cuff with stylus holder, head pointing system, Mousekeys, onscreen scanning keyboard with switch(es)	
4. Travel to registration site	N/A	N/A	
5. Enter registration site	N/A	Automatic door	
6. Mailing forms	Scanner/email using **adaptive computer access software and/or hardware**	N/A	
7. Calling election office	Adapted phone (large buttons, switch operated, voice controlled)	N/A	
8. Pull documentation together for registration	**Adaptive computer access software and/or hardware**	Adaptive computer access software and/or hardware	
LEARNING ABOUT CANDIDATES AND BALLOT ISSUES, LEARNING ABOUT HOW ELECTIONS WORK (PROCESS)			
9. Reading text from books, newspapers, magazines, websites, email, social network sites, TV	Headstick, mouthstick, cuff with stylus holder; Book stand, copy stand, **Adaptive computer access software and/or hardware**	N/A	
10. Hearing reports from TV, radio, websites, live events, direct and phone contact with others	N/A	N/A	
11. Reading graphics, text from snail mail, websites, newspapers, TV	Copy holder, mouthstick, headstick, Voice controlled remote	N/A	
12. Attend political rally or town hall meeting to hear candidates	N/A	N/A	

FINDING OUT WHEN AND WHERE ELECTIONS WILL BE HELD AND OPTIONS FOR VOTING			
13. Hearing information from others directly (face to face, phone), TV, radio	N/A	N/A	
14. Accessing a calendar and assigning appointment time/place to a date.	N/A	N/A	
GETTING TO THE POLLING SITE			
15. Locate, identify, access needed documents	Headstick, mouthstick	N/A	
16. Present documents at poll	N/A	N/A	
SIGNING IN AND GETTING YOUR BALLOT			
17. Travel to poll site	Vehicle with adapted hand, adapted controls	N/A	
18. Enter poll site	N/A	Ramp, automatic door, lever door handle	
19. Maneuver in polling site	N/A	N/A	
20. Position for access to voting booth/machine	N/A	N/A	
21. Speak to poll worker	N/A	N/A	
LEARNING HOW TO MARK YOUR BALLOT			
22. Read paper instructions	Copy holder, page turner, mouthstick, headstick	Copy holder, page turner	
23. Read instructions on digital machine	Switch access to plug into voting machine	Switch access for moving through pages	
24. Hear instructions from poll worker	N/A	N/A	
25. Hear instructions from digital machine	N/A	N/A	
CASTING YOUR BALLOT			
26. Mark paper ballot with pen, stylus	Cuff with pen holder, mouth stick, head stick	?	Customized accessible interfaces for public systems, customized accessible interfaces for personal devices, and gesture recognition
27. Type on digital machine	Head stick, mouth stick, cuff with pen holder	Cuff with pen holder, voting machine with scanning and adaptive switch(es)	
28. Press buttons on machine	Head stick, mouth stick, cuff with pen holder	Cuff with pen holder, voting machine with scanning and adaptive switch(es)	
29. Flip levers on machine	Head stick, mouth stick, cuff with pen holder	Cuff with pen holder	
30. Transport paper ballot to scanner or poll worker	Mouth stick with grabber on the end	Voting machine with feature that transports ballot to proper location	

Table 3: Visual impairment

The fundamental process adaptation for blind voters is the conversion from print or electronic text to speech (or Braille, tactile) of all information the voter needs throughout the voting process. There are plenty of software tools to make this happen for electronic text. An added level of software is needed to do this for print – optical character recognition (OCR). With that comes an added level of complexity to the conversion and subsequent increase in likelihood of conversion error.

Table 3: Visual impairment

TASK	ASSISTIVE TECHNOLOGY (personal)	ASSISTIVE TECHNOLOGY (provided to public or at polling place)	EMERGING TECHNOLOGY
REGISTERING TO VOTE			
1. Reading text from paper forms, websites	Portable text-speech device (Intel Reader), scanner & optical character recognition (OCR) software with speech output, screen readers	N/A	
2. Writing text, signing paper forms	Writing guide	N/A	
3. Filling out online forms (computer typing, mouse, stylus)	Screen reading software, Braille reader	N/A	
4. Travel to registration site	Mobile device with speech/Braille output navigation system, public transportation app for mobile device with speech/Braille output	N/A	
5. Enter registration site	Cane	N/A	
6. Mailing forms	N/A	N/A	
7. Calling election office	N/A	N/A	
8. Pull documentation together for registration	Scanner & OCR with speech output	N/A	
LEARNING ABOUT CANDIDATES AND BALLOT ISSUES, LEARNING ABOUT HOW ELECTIONS WORK (PROCESS)			
9. Reading text from books, newspapers, magazines, websites, email, social network sites, TV	Scanner & OCR with speech output, screen reading software	N/A	
10. Hearing reports from TV, radio, websites, live events, direct and phone contact with others	TV Speak (through PC)	N/A	
11. Reading graphics, text from snail mail, websites, newspapers, TV	Scanner & OCR with speech output, screen reading software	N/A	
12. Attend political rally or town hall meeting to hear candidates	Mobile device with speech/Braille output navigation system, public transportation app for mobile device with speech output	N/A	
FINDING OUT WHEN AND WHERE ELECTIONS WILL BE HELD AND OPTIONS FOR VOTING			
13. Hearing information from others directly (face to face, phone), TV, radio	N/A	N/A	
14. Accessing a calendar and assigning appointment time/place to a date.	Braille mobile device, screen reading software		

GETTING TO THE POLLING SITE			
15. Locate, identify, access needed documents	Portable text-speech device	Scanner & OCR with speech output, screen reading software	
16. Present documents at poll	N/A	N/A	
SIGNING IN AND GETTING YOUR BALLOT			
17. Travel to poll site	Mobile device with speech/Braille output navigation system, public transportation app for mobile device with speech output	N/A	
18. Enter poll site	Cane	N/A	
19. Maneuver in polling site	Cane	?	Way-finding with mobile devices
20. Position for access to voting booth/machine	Cane	?	
21. Speak to poll worker	N/A	N/A	
LEARNING HOW TO MARK YOUR BALLOT			
22. Read paper instructions	Portable text-speech device, scanner & OCR software with speech/Braille output	Portable text-speech device, scanner & OCR software with speech/Braille output	
23. Read instructions on digital machine		Text-to-speech option on voting machine	Visual flat screen display readers
24. Hear instructions from poll worker	N/A	N/A	
25. Hear instructions from digital machine	N/A	N/A	
CASTING YOUR BALLOT			
26. Mark paper ballot with pen, stylus	Writing guide	Writing guide	
27. Type on digital machine			
28. Press buttons on machine	Portable text-speech device	Braille labels	
29. Flip levers on machine	Portable text-speech device	Braille labels (?)	
30. Transport paper ballot to scanner or poll worker	Cane. portable text-speech device	Voting machine with feature that transports ballot to proper location	

Table 4: Hearing impairment

Throughout the voting process there are tasks involving communication with others. These tasks represent the primary challenge faced by people who are deaf as they participate in the process. That said, there are long used, effective strategies and technologies available to facilitate communication between the deaf voter and those they need to interact with during the process.

Table 4: Hearing impairment

TASK	ASSISTIVE TECHNOLOGY (personal)	ASSISTIVE TECHNOLOGY (provided to public or at polling place)	EMERGING TECHNOLOGY
REGISTERING TO VOTE			
1. Reading text from paper forms, websites	N/A	N/A	
2. Writing text, signing paper forms	N/A	N/A	
3. Filling out online forms (computer typing, mouse, stylus)	N/A	N/A	
4. Travel to registration site	N/A	N/A	
5. Enter registration site	N/A	N/A	
6. Mailing forms	N/A	N/A	
7. Calling election office	TDD		
8. Pull documentation together for registration	N/A	N/A	
LEARNING ABOUT CANDIDATES AND BALLOT ISSUES, LEARNING ABOUT HOW ELECTIONS WORK (PROCESS)			
9. Reading text from books, newspapers, magazines, websites, email, social network sites, TV	N/A	N/A	
10. Hearing reports from TV, radio, websites, live events	Closed captioning, amplified headphones, hearing aid, phone amplifier	N/A	
11. Reading graphics, text from snail mail, websites, newspapers, TV	N/A	N/A	
12. Attend political rally or town hall meeting to hear candidates	Hearing aid	(Live transcription, sign language interpreter)	
FINDING OUT WHEN AND WHERE ELECTIONS WILL BE HELD AND OPTIONS FOR VOTING			
13. Hearing information from others directly (face to face, phone), TV, radio	Hearing aid, TDD, closed captioning, amplified headphones	N/A	
14. Accessing a calendar and assigning appointment time/place to a date.	N/A	N/A	
GETTING TO THE POLLING SITE			
15. Locate, identify, access needed documents	N/A	N/A	
16. Present documents at poll	N/A	N/A	

SIGNING IN AND GETTING YOUR BALLOT			
17. Travel to poll site	N/A	N/A	
18. Enter poll site	N/A	N/A	
19. Maneuver in polling site	N/A	N/A	
20. Position for access to voting booth/machine	N/A	N/A	
21. Speak to poll worker	AAC device	Typing communication aid (Lightwriter, Interpretype, other)	
LEARNING HOW TO MARK YOUR BALLOT			
22. Read paper instructions	N/A	N/A	
23. Read instructions on digital machine	N/A	N/A	
24. Hear instructions from poll worker	Voice recognition – mobile device	Typing communication aid (Lightwriter, Interpretype, other	
25. Hear instructions from digital machine	Voice recognition – mobile device	(presented in visual format)	
CASTING YOUR BALLOT			
26. Mark paper ballot with pen, stylus	N/A	N/A	
27. Type on digital machine	N/A	N/A	
28. Press buttons on machine	N/A	N/A	
29. Flip levers on machine	N/A	N/A	
30. Transport paper ballot to scanner or poll worker	N/A	N/A	

Table 5: Deaf/Blind

As with blind voters, the fundamental process adaptation for deaf/blind voters is the conversion of print to some form the deaf/blind voter can perceive and understand. But in this case, conversion to speech is not a usable alternative. Information must be provided in a tactile form.

Table 5: Deaf/Blind

TASK	ASSISTIVE TECHNOLOGY (personal)	ASSISTIVE TECHNOLOGY (provided to public or at polling place)	EMERGING TECHNOLOGY
REGISTERING TO VOTE			
1. Reading text from paper forms, websites	Scanner/OCR to Braille output	Scanner/OCR to Braille output	
2. Writing text, signing paper forms			
3. Filling out online forms (computer typing, mouse, stylus)	Braille display	Braille display	
4. Travel to registration site	Mobile device with Braille output navigation system, public transportation app for mobile device with Braille output	N/A	
5. Enter registration site	cane	N/A	
6. Mailing forms	Braille translator, printer	N/A	
7. Calling election office	Braille TDD	N/A	
8. Pull documentation together for registration	Braille labels	N/A	
LEARNING ABOUT CANDIDATES AND BALLOT ISSUES, LEARNING ABOUT HOW ELECTIONS WORK (PROCESS)			
9. Reading text from books, newspapers, magazines, websites, email, social network sites, TV	Scanner/OCR to Braille output	N/A	
10. Hearing reports from TV, radio, websites, live events	?	N/A	
11. Reading graphics, text from snail mail, websites, newspapers, TV	Scanner/OCR to Braille output	N/A	
12. Attend political rally or town hall meeting to hear candidates	?	?	
FINDING OUT WHEN AND WHERE ELECTIONS WILL BE HELD AND OPTIONS FOR VOTING			
13. Hearing information from others directly (face to face, phone), TV, radio	Braille TDD, Speech recognition to Braille, speech to Braille reporting	N/A	
14. Accessing a calendar and assigning appointment time/place to a date.	Braille calendar	N/A	

GETTING TO THE POLLING SITE			
15. Locate, identify, access needed documents	Braille labels	N/A	
16. Present documents at poll	N/A	N/A	
SIGNING IN AND GETTING YOUR BALLOT			
17. Travel to poll site	Cane	N/A	
18. Enter poll site	Cane	N/A	
19. Maneuver in polling site	Cane	?	
20. Position for access to voting booth/machine	Cane	N/A	
21. Speak to poll worker	Portable Braille notetaker with speech output (e.g. Braille Lite)	N/A	
LEARNING HOW TO MARK YOUR BALLOT			
22. Read paper instructions	Scanner/OCR to Braille output	Scanner/OCR to Braille output	
23. Read instructions on digital machine	?	Scanner/OCR to Braille output	Visual flat screen display readers
24. Hear instructions from poll worker	Speech recognition to Braille, speech to Braille reporting	Braille translator	
25. Hear instructions from digital machine	Speech recognition to Braille, speech to Braille reporting	(Braille output option on voting machine)	
CASTING YOUR BALLOT			
26. Mark paper ballot with pen, stylus	N/A	N/A	Customized accessible interfaces for public systems, customized accessible interfaces for personal devices, and way-finding with mobile devices
27. Type on digital machine	N/A	N/A	
28. Press buttons on machine	N/A	Braille labels	
29. Flip levers on machine	N/A	Braille labels	
30. Transport paper ballot to scanner or poll worker	?	?	

Table 6: Cognitive impairment

As for other types of disabilities, the adaptation of the voting process for people with cognitive disabilities revolves around conversion of information to a form the person can digest and process. People with reading disabilities may just need text-to-speech conversion. However, depending on the level and type of cognitive impairment, the voter may need information presented in more "plain language." Currently, the author is aware of no assistive technology products available to consumers that make this kind of conversion.

Table 6: Cognitive impairment

TASK	ASSISTIVE TECHNOLOGY (personal)	ASSISTIVE TECHNOLOGY (provided to public or at polling place)	EMERGING TECHNOLOGY
REGISTERING TO VOTE			
1. Reading text from paper forms, websites	Portable text-speech device, scanner & OCR software with speech output, screen readers	N/A	
2. Writing text, signing paper forms	N/A	N/A	
3. Filling out online forms (computer typing, mouse, stylus)	N/A	N/A	
4. Travel to registration site	N/A	N/A	
5. Enter registration site	N/A	N/A	
6. Mailing forms	N/A	N/A	
7. Calling election office	N/A	N/A	
8. Pull documentation together for registration	N/A	N/A	
LEARNING ABOUT CANDIDATES AND BALLOT ISSUES, LEARNING ABOUT HOW ELECTIONS WORK (PROCESS)			
9. Reading text from books, newspapers, magazines, websites, email, social network sites, TV	Portable text-speech device, scanner & OCR software with speech output, screen readers	N/A	
10. Hearing reports from TV, radio, websites, live events		N/A	
11. Reading graphics, text from snail mail, websites, newspapers, TV	Portable text-speech device, scanner & OCR software with speech output, screen readers	N/A	
12. Attend political rally or town hall meeting to hear candidates	N/A	N/A	
FINDING OUT WHEN AND WHERE ELECTIONS WILL BE HELD AND OPTIONS FOR VOTING			
13. Hearing information from others directly (face to face, phone), TV, radio		N/A	
14. Accessing a calendar and assigning appointment time/place to a date.	Prompting app on smart device	N/A	
GETTING TO THE POLLING SITE			
15. Locate, identify, access needed documents	Simple organizational tools/apps on smart device	N/A	
16. Present documents at poll		N/A	

SIGNING IN AND GETTING YOUR BALLOT			
17. Travel to poll site	N/A	N/A	
18. Enter poll site	N/A	N/A	
19. Maneuver in polling site	Portable text-speech device (e.g. IntelReader for reading signs)	N/A	
20. Position for access to voting booth/machine	N/A	N/A	
21. Speak to poll worker	N/A	N/A	
LEARNING HOW TO MARK YOUR BALLOT			
22. Read paper instructions	Portable text-speech device, scanner & OCR software with speech output, screen readers	scanner & OCR software with speech output, screen readers	
23. Read instructions on digital machine	?	(speech output option for instructions on voting machine)	Visual flat screen display readers
24. Hear instructions from poll worker	N/A	N/A	
25. Hear instructions from digital machine	N/A	N/A	
CASTING YOUR BALLOT			
26. Mark paper ballot with pen, stylus	N/A	N/A	Customized accessible interfaces for public systems, customized accessible interfaces for personal devices, augmented reality, and way-finding with mobile devices
27. Type on digital machine	N/A	N/A	
28. Press buttons on machine	N/A	N/A	
29. Flip levers on machine	N/A	N/A	
30. Transport paper ballot to scanner or poll worker	N/A	N/A	

Table 7: AT for functional activities in voting

Another, simpler way to look at AT as it facilitates voting for people with disabilities is to group it based on the general tasks involved in multiple elements of the voting process. For example, both the registration process and voting at the poll may involve writing and the manipulation of paper. Transportation may also be necessary for both registration and for casting a vote.

This table does not distinguish between the type of disability, beyond what can be derived from the listing of particular assistive devices. It is true that people with different types of disabilities may use the same AT to accomplish the same tasks. Someone with a cognitive disability, for example, may need to use a text reading device, as would someone with a visual impairment.

Six general functions involved in the voting process are listed below.

- Transportation

- Reading text

- Communication (receptive and expressive)

- Writing (generating text)

- Physically manipulating paper, tools

- Executive functioning

Each of the functions must be carried out in some way in order to complete at least some of the overall process of voting. In order to do it independently and successfully, people with disabilities may need to employ one or more of the assistive technologies listed in that group. Within each group the types of AT to be used are divided into more common products and devices, specialized AT, and emerging AT.

Table 7: AT for functional activities in voting

COMMON ASSISTIVE TECHNOLOGY	SPECIALIZED ASSISTIVE TECHNOLOGY	EMERGING TECHNOLOGIES WITH POTENTIAL AT APPLICATIONS
TRANSPORTATION		
Wheelchair	Personal vehicle adapted with hand controls	Way-finding with mobile devices
Walker	Mobile device with speech/Braille output navigation system, public transportation app for mobile device with speech/Braille output	
Cane	Mobile device with Braille output navigation system, public transportation app for mobile device with Braille output	
White cane		
READING TEXT		
Book stand	Screen reading software	Visual flat screen display readers
Copy stand	head pointing system (electronic)	
Mouthstick	eyegaze system	
Cuff with stylus holder	onscreen scanning keyboard with switch(es)	
Head stick	MouseKeys	
Braille labels	Page turner (switch operated)	
	Portable text-speech device (Intel Reader), scanner & optical character recognition (OCR) software with speech output	Customized accessible interfaces for personal devices
	Braille reader	Customized accessible interfaces for public systems
	Braille mobile device, screen reading software	Gesture recognition
	Scanner/OCR to Braille output	
	TV Speak (through PC)	
	Braille computer display	
	Braille labels	

COMMUNICATION (receptive and expressive)		
	Adapted phone (large buttons, switch operated, voice controlled)	Customized accessible interfaces for personal devices
	phone amplifier	Customized accessible interfaces for public systems
	TDD	Gesture recognition
	AAC device	
	Hearing aid	
	Braille TDD	
	Speech recognition to Braille, speech to Braille reporting	
	Portable Braille notetaker with speech output (e.g. Braille Lite)	
	Closed captioning	
	Amplified headphones	
	Braille computer display	
	Braille TDD	
WRITING (GENERATING TEXT)		
Signature guide	Voice controlled remote	Customized accessible interfaces for personal devices
Cuff with pen holder	Speech recognition software	Customized accessible interfaces for public systems
Writing guide	Voice recognition – mobile device	Gesture recognition
	Portable Braille notetaker	
	Braille translator, printer	
PHYSICALLY MANIPULATE PAPER, TOOLS		
	Mouth stick with grabber on the end	
EXECUTIVE FUNCTION		
Braille watch	Prompting app on smart device	Customized accessible interfaces for personal devices
	Simple organizational tools/apps on smart device	Customized accessible interfaces for public systems
	Braille calendar	Augmented reality
	Watch with multiple alarm settings	Way-finding with mobile devices